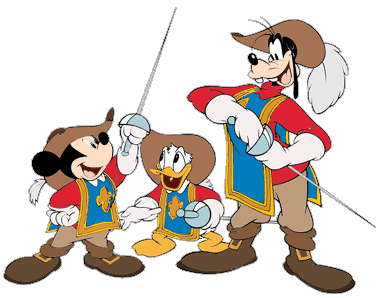
**Photosynthesis Saboteur**

Approximate length of the activity (40 minutes – 1 hour)

**Purpose**: This activity is meant to be a formative assessment of students’ understanding of the structure of chlorophyll, the process of photoexcitation, the steps involved in noncyclical electron flow, and cyclical electron flow. It also gives students an opportunity practice calculating the amount of ATP/ NADPH/ photons/ Hydrogen/ electrons that are associated with the two electron flow pathways.

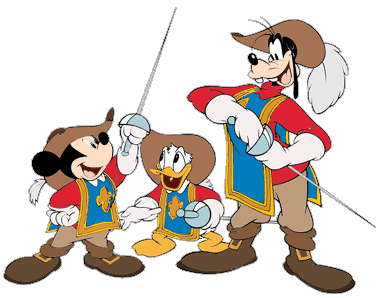
**Materials required**:

* 10 envelopes
* Printed and cut-out manipulative for each station
* 10 copies (1 sheet per group) of the “Investigation forms”

**Background story**: There are 10 envelopes containing components and parts associated with photosynthesis. Unfortunately, a few saboteurs snuck into my envelopes last night and stole key components and pieces in the photosynthesis process. Now photosynthesis is ruined and cannot occur. As investigators, you and your group must investigate each of the 10 cases. You must figure out what has been stolen as well as do a few calculations.

**Setup**:

1. Organize class into groups of 2-3 students
2. Assign out a role to each individual in the team
   1. 3 possible roles
      1. **Writer** = responsible for writing down the group’s response to the answer on the team’s “investigation form
      2. **Discussion Facilitator** = in charge of ensuring that each person has equal input in the group’s problem solving process and will also be responsible for summarizing the team’s discussion to the teacher whenever the teacher comes to conference with the group. They are also responsible for encouraging their group members throughout the activity.
      3. **Saboteur** = in charge of helping arrange the photosynthesis manipulatives into the right order. They will also be responsible for mixing up the manipulatives at the end of each round so that the groups that follow will not have the correct answer. Saboteurs can also try and trick other groups by arranging the pieces in the wrong order for the other groups.
3. After each “round” ends, call for the student’s attention. Have the writers raise their writing utensils into the air and have them hand their pen/pencil to another member in their team. They have just passed on their “writer” role to one of their partner. And each person in that group will then swap roles and have new roles for the next station/ round.
4. After all the groups have completed all 10 of the stations, inform the groups that each role has a new specific job
   1. **Writer**= Hand in their group’s “investigation form” to the teacher
   2. **Discussion Facilitator** = ensure that the surrounding area of the station is clean
   3. **Saboteur**= gather the manipulatives, placed them back into the envelopes, and hand them packages back to the teacher.
5. After this activity is completed (roughly 5 minutes per round), give an opportunity for the students to bring up questions that they may have formed as a result of that activity. If there are questions the students are having trouble understanding, then the question can be placed on the board, and fellow classmates can be chosen to go to the front of the room and guide their peers through how they solved the question. There may be multiple ways of solving a calculation question, so ensure you take the time to ask students to share alternative problem solving strategies if possible.
6. The questions from each station can then be posted online, and the students can go back and review those questions independently at home to ensure that they understand the concept.
7. The “investigation forms” can be used as a formative assessment to identify areas/ topics where students may need some more support in.

Team Member’s names: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Investigation Team Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |
| --- | --- |
| **Station #** | **Answers (please include steps in your calculations as well as explanations to your answers)** |
| 1 |  |
| 2 |  |
| 3 |  |
| 4 |  |
| 5 |  |
| 6 |  |
| 7 |  |
| 8 |  |
| 9 |  |
| 10 |  |

**Station 1**

Arrange the pieces into the correct order and calculate the amount of ATP produced from non-cyclic electron flow when a total of 72 electrons have travelled through the **entire pathway**. (assume that all the hydrogens in this question come from the stroma) Did the Saboteur do anything to ruin your station (hint: details are important)

Thylakoid membrane

Thylakoid membrane

Photosystem II

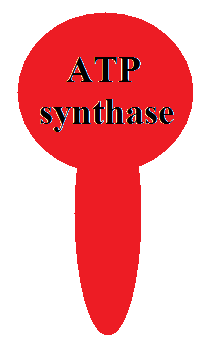
PS700

Photosystem I

PS680

b6-f

Complex



**NADP reductase**

**Station 2:**

Arrange the pieces into the correct order and calculate the amount of ATP produced from cyclic electron flow when PS700 absorbed 36 photons. If you think, a saboteur meddled with your station, please state which pieces should/ should not be included in your diagram.

Thylakoid membrane

Thylakoid membrane

Photosystem I

PS700

Photosystem II

PS680

Thylakoid membrane

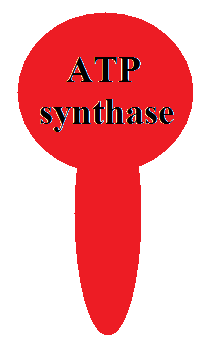
Photosystem I

PS700

Thylakoid membrane

b6-f

Complex



**NADP reductase**

**Station 3:**

Arrange the pieces into the correct order. Identify all of the missing components in the non-cyclical electron flow pathway. And calculate how many NADPH would be produced from 64 photons of light hitting the non-cyclical electron flow pathway. (hint: does the sun show favouritism in who it gives sunlight to?)

Photosystem I

PS700

Thylakoid membrane

Thylakoid membrane

b6-f

Complex

**NADP reductase**

**Station 4:**

Organize all the components of the non-cyclical electron flow pathway into the right order. List all the components that have been stolen by the Saboteur. If there was no water provided to the plant for a long period of time, and it was exposed to only 80 photons of light, how many ATP would be produced?

Thylakoid membrane

Thylakoid membrane

Photosystem I

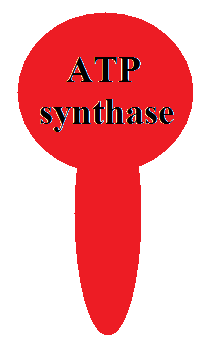
PS700

Photosystem II

PS680

b6-f

Complex

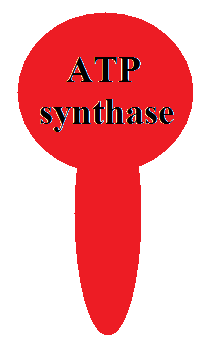


**Station5:**

Identify all the missing components of the non-cyclical electron flow pathway. If your plant had a disease where all the z proteins denatured and disappeared. After a long period of time passes by, how many ATP would be produced from if this system were to be exposed to 84 photons of light.

Photosystem II

PS680



Thylakoid membrane

Thylakoid membrane

**Station 6:**

Organize all the pieces of photoexcitation into the correct order. Identify all the missing components that have been stolen by the saboteur. Which type chlorophyll would release more fluorescence and why?

**Chrlorophyll molecule**

**Photon (florescence)**

**Station 7:**

**Chlorophyll b**

**Chlorophyll a**

**xanthophylls**

**β-carotene**

**anthocyanins**

**xanthophylls**

**Chlorophyll b**

Assemble a photosystem. If there was no pheophytin found in the photosystem, what type of energy will be produced from the photosystem and why?

**Station 8:**

Organize all the components of the cyclical electron flow pathway into the right order. Are there any pieces that should not be in this pathway? Calculate how many electrons will have passed through the pathway in order to generate 64 ATP. Also calculate how many H ions are **pumped into** the thylakoid lumen in this scenario

Thylakoid membrane

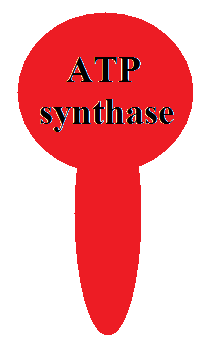
Thylakoid membrane

Photosystem I

PS700

Photosystem II

PS680



b6-f

Complex

**NADP reductase**

**Station 9:**

Match the pigments with the color of light that is reflected. Identify piece(s) that have been planted into the envelope by the saboteur.

**red, violet, and blue**

**Blue-green**

**Yellow-green**

**xanthophylls**

**Blue-violet**

**Yellow**

**yellow-orange-red**

**Chlorophyll a**

**β-carotene**

**Chlorophyll b**

**anthocyanins**

**Station 10:**

Assemble a chlorophyll a and b molecule and place the correct label over each molecule.

**Label: Chlorophyll b**

**Label: Chlorophyll a**

Hydrocarbon tail

Hydrocarbon tail

Which molecule will look a darker shade of green and why?

**Porphyrin ring**

**Porphyrin ring**

**Answer key to Photosynthesis Sabotage carousel Activity**

Station 1= 36ATP, PSII suppose to absorb 680nm of light , and PSI suppose to absorb 700nm of light

Station2= 18 ATP, PSII and NADP Reductase should not be included

Station 3= 16 NADPH (2photon hits PSII and 2 photon hits PSI in order to have a total of two electrons reach NADP reductase) PSII, PQ, Ferrodoxin, ATP synthase

Station 4= 40 ATP, PQ, Pc, NADP reductase

Station 5= PS2, PQ, Ferrodoxin, b6-f complex. 42 ATP

Station6= heat and photon. Chlorophyll a because it is able to absorb a shorter wavelength of light and a higher amount of energy than chlorophyll b.

Station7= heat and fluorescence, because if there is no primary electron acceptor present to disassociate the electron from the chlorophyll, the electron will drop back down to ground state and will release its energy as heat and florescence.

Station 8= 128 electrons and 256 hydrogen, PSII and NADP reductase

Station 9= chlorophyll a- blue green, cholorophyll b-yellow green, beta carotene-yellow orange red, anthrocide= red, violet and blue, xanthophylls-yellow

Saboteur= blue-violet,

Station 10= chlorophyll b, because it can’t absorb as high of an energy of light as chlorophyll a. This means that the chlorophyll b will reflect a higher energy light than chlorophyll a. Higher energy light is a darker color (violet/blue).